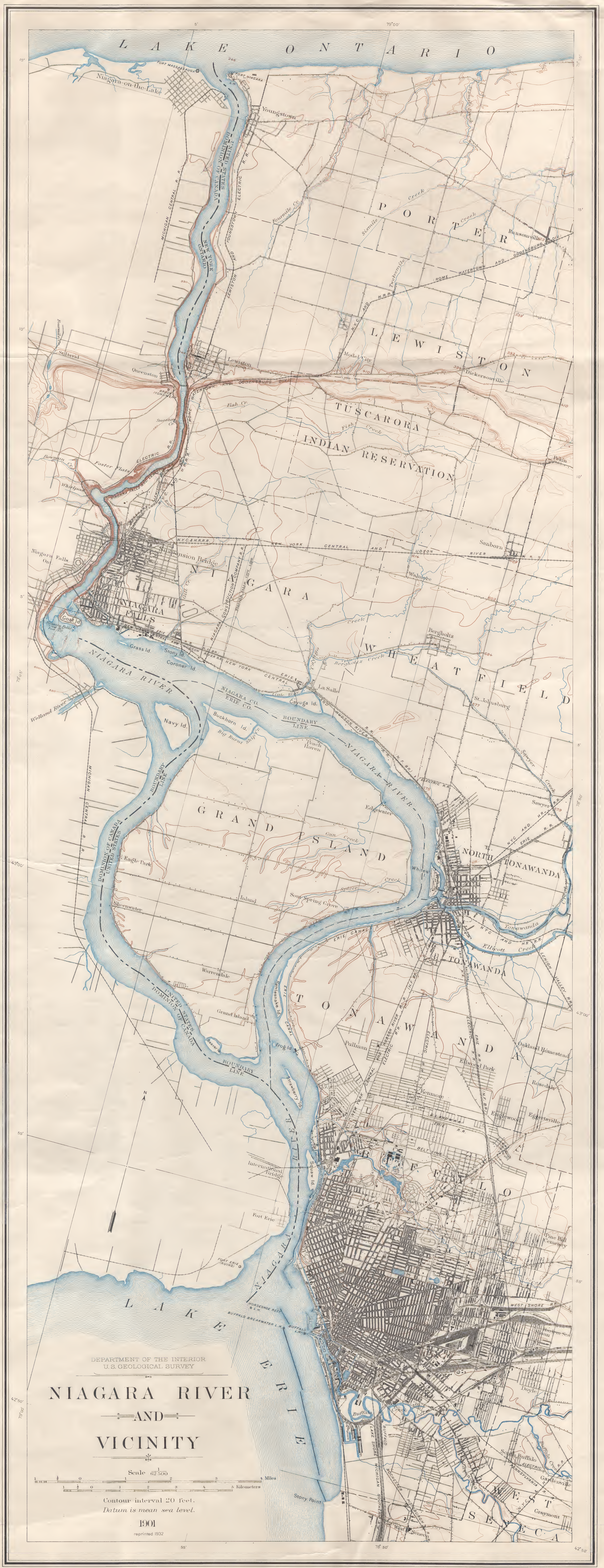

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

NIAGARA RIVER
AND
VICINITY

Scale $\frac{1}{62\,500}$

Contour interval 20 feet.
Datum is mean sea level.

1901

reprinted 1932

Henry Gannett, Chief Topographer.
H.M. Wilson, Geographer in charge.
Triangulation by U.S. Lake Survey.
Topography by U.S. Lake Survey, Frank Sutton, J.H. Wheat and W.W. Gilbert.
Surveyed in 1893 and 1900
in cooperation with the State of New York,
represented by the Department of Public Works
Polyconic projection. Nortn American datum

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MAP OF NIAGARA RIVER AND VICINITY

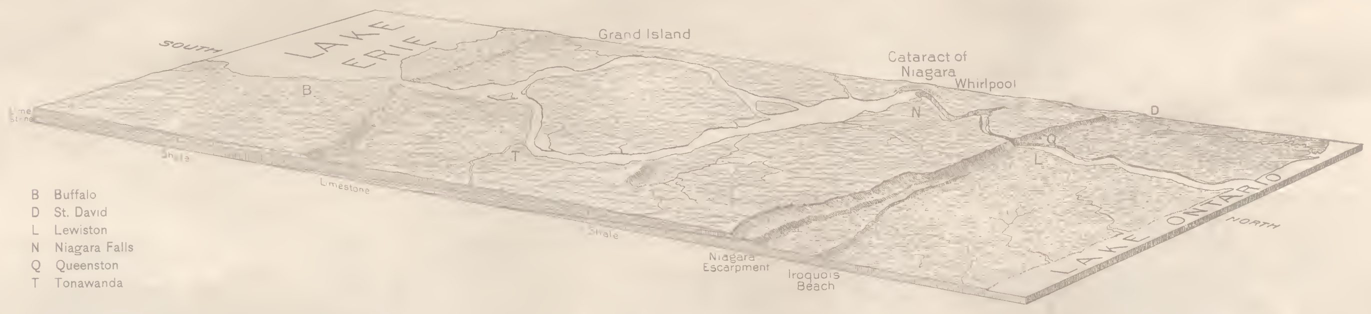
The United States Geological Survey is making a topographic atlas of the United States which is published in rectangular sheets, each sheet showing an area bounded by parallels and meridians and representing either the fourth part or the sixteenth part of a "square degree." Full information in regard to the atlas of the United States may be obtained by addressing the Director, United States Geological Survey, Washington, D. C.

The map of Niagara River has been made by combining parts of several atlas sheets. It represents a portion of the State of New York and a narrow strip of the Canadian province of Ontario. The work of the Survey stops at the international boundary, and data for a complete map of the Canadian part of the area are not available.

The features shown on the map are printed in three colors. The *culture*, including names, roads, railroads, and other artificial features, is in black. The *water*, including lakes, ponds, streams, and canals, is in blue. The *relief*, including contour lines and figures to indicate altitude, is in brown.

The surface of Lake Ontario is 246 feet above sea level. The outline of the lake shore is determined by the contact of this surface with the slopes of the land. If water were added to the lake until it became 14 feet deeper the surface would then be 260 feet above sea level; the lake would be larger and its shore line would be at a new place. On the map the brown line nearest to the lake represents the theoretic position of the shore with the lake surface 14 feet higher. It is called the contour line of 260 feet. If one should walk on the land along the course indicated by this line he would go neither up nor down but would be continually at the height of 260 feet above the sea. The second brown line from the lake is the contour line of 280 feet; and the next beyond is the contour line of 300 feet, which, for distinction, is made a heavier line and is also numbered with brown figures. If the ground were perfectly smooth and sloped evenly toward the lake, these lines would be regular and parallel, but as the ground is uneven they are irregularly curved, and their curvature thus tells something as to the shape of the ground. As the space between each two adjacent contour lines represents a vertical distance of 20 feet, the contour lines are close together where the slope of the ground is steep and far apart where it is gentle. Thus, for example, there is a place south of Lewiston where ten contour lines are crowded into the space of one-eighth of an inch, and this means that in the horizontal distance of one-eighth of a mile there is an ascent of 180 feet.

The following description of the geologic history of Niagara River was prepared by G. K. Gilbert in 1901, but the statements concerning power available and utilized have been brought up to date (1921).



BIRD'S-EYE VIEW OF NIAGARA RIVER

Showing the upper and lower plains, the Niagara escarpment, and the gorge

The view represents the area covered by the map as if it were the top of a solid block cut from the earth. The bottom of the block corresponds to sea level, and its side shows the arrangement of the rocks. The vertical scale is five times the horizontal.

Niagara River is the outlet of Lake Erie and flows northward 34 miles to Lake Ontario. The vertical descent from lake to lake is 327 feet. The average flow of water is 222,000 cubic feet per second. The river is navigable from its head to Chippawa, at the mouth of Welland River, 17 miles, and from Lewiston to its mouth, 7 miles. It affords enormous water power, of which about 6,000,000 horsepower is readily available and 700,000 horsepower has already been utilized. Its main channel forms part of the international boundary between the United States and Canada.

Plains and escarpment.

The country traversed by the river consists of two plains, each extending for a considerable distance east and west beyond the field of the map. The upper plain has a gently undulating surface, which stands at a general height of 600 feet above sea level. The lower plain borders Lake Ontario and is comparatively smooth except where streams have washed out narrow valleys; its south edge has a height of 380 to 400 feet, and it slopes northward to a height of about 260 feet at the lake shore. Where the plains approach each other the upper is about 200 feet above the lower and they are separated by a steep bluff—the Niagara escarpment. In some places this bluff is divided into two parts, so that the descent from the upper plain to the lower is made by two steps.

Rocky framework.

When a boring is made on the shore of the river near its head the first rock encountered is limestone. After passing through this to a depth of 50 to 100 feet the drill reaches a soft shale, in which it continues for 400 feet. Then it encounters another limestone, 200 feet thick, and below that a body of shale nearly 2,000 feet thick, in which there are a few minor beds of limestone and sandstone. Each of these formations is a broad, flat sheet, not quite level but inclining a little toward the south. The upper limestone can be traced eastward in New York and westward in Canada for some distance. Its southward inclination carries it under the bottom of Lake Erie. The lower limestone, 500 feet underground at Buffalo, rises gradually northward and reaches the surface of the plain near the city of Niagara Falls. Thence to the line of the escarpment it can be seen at many points, but it ends along that line, its lower part constituting the crest of the escarpment. This formation is called the Niagara limestone. The lower shale, 700 feet below the ground at Buffalo, comes to the surface in the escarpment and may be seen at many points in the lower plain. All these rocks are more or less overlain and concealed by beds of clay, loam, sand, and other loose material, which are collectively called *drift*.

Features of the river.

Opposite Buffalo, where the river crosses the edge of the upper limestone, there is a strong rapid. Thence to Goat Island the current is slower and the stream is broad, dividing and reuniting so as to inclose several islands. The river here has no valley but flows along the surface of the upper plain. At the head of Goat Island it reaches the Niagara limestone and immediately becomes swift and comparatively shallow, tumbling over ledge after ledge in a long rapid. At the cataract of Niagara it leaps from the upper plain down into a narrow gorge, through which it runs with many rapids to the escarpment. Where it issues from the escarpment it has nearly the level of Lake Ontario, and it flows to the lake in a broad, deep channel sunk somewhat below the level of the lower plain.

Origin of the gorge.

The gorge is a narrow slot or trench dividing the upper plain. In its walls can be seen the Niagara limestone and lower formations, all corresponding accurately in height on the two sides. It is evident that they were once continuous from side to side of the gorge and are separated now only because the intervening parts have been removed. The gorge has, in fact, been dug out by the river itself, the work being performed chiefly by the cataract. The way in which the work is done is connected with the arrangement of the layers of rock. At the top is the Niagara limestone, a hard, strong rock, with a thickness at the cataract of 80 feet; below are soft, weak shales, containing only a few ledges of harder material. In the principal division of the cataract, called the Horseshoe Fall, the falling water plunges into a deep pool, which is kept in fierce agitation. The surging water wears away the shale and thus gradually deprives the limestone bed of its support. From time to time blocks of the limestone break away, falling into the pool below. Each fall of limestone makes the position of the cataract retreat upstream and thus lengthens the gorge. Between 1842, when a careful map of the cataract was made, and 1891, when the mapping was repeated, the cataract retreated and the gorge was lengthened about 200 feet, the average rate being between 4 and 5 feet a year.

Details of the gorge.

The Whirlpool.

The gorge is not perfectly uniform in width and depth. Where it is comparatively narrow and shallow there are rapids in the river, the water dashing over blocks of fallen rock. Where it is somewhat broader and deeper there are pools, with slower current and many eddies. The pool just below the cataract is about 2 miles long and 100 to 200 feet deep. Then begins the Whirlpool Rapid, where the depth of water is only 50 feet and the velocity reaches 30 miles an hour. A long pool succeeds, with a special enlargement, known as the Whirlpool, and then a longer rapid, extending to the mouth of the gorge. The Whirlpool occupies a deep oval basin at a point where the river makes a square turn to the right; the current first swings to the left and then, making a complete loop, passes under itself before emerging from the pool. This locality is further notable because the limestone, shale, and other rocks disappear for a space from the Canadian wall, being replaced by a mass of drift. There is an ancient channel here, of which mention will be made again.

Youth of the river.

As the cataract is sawing the slot longer at the rate of 4 to 5 feet a year, it has been inferred that the complete division of the plateau back to Lake Erie is only a question of time; and as the cataract has not yet accomplished that task but has sawed a slot only 7 miles long, it may also be inferred that the stream has been at work for only a relatively short time. It is not possible for the river to have flowed here for the millions of years that constitute a geologic period without accomplishing much more erosion, and it is therefore inferred that the Niagara is not one of the old rivers of the earth but is comparatively young.

Origin of the river.

The beginning of the river is intimately associated with the glacial or Pleistocene epoch. Before that time Lake Erie and Lake Ontario did not exist and there was a very different system of rivers in the region. In the early part of the epoch glaciers were formed on the highlands of Canada and gradually grew and spread until they covered all the region of the Great Lakes. They eroded the land in places and deposited the eroded material elsewhere in the form of drift. Then they melted back so as to uncover the lake region, making an interglacial stage, and afterward they again grew large. These oscillations were repeated several times, so that the Pleistocene epoch was composed of several glacial stages separated by interglacial stages. Each interglacial stage had its own system of lakes and rivers, and in one of these stages a great river traversed the Niagara district, crossing the escarpment a few miles west of the mouth of the Niagara gorge. Like the Niagara, it made a gorge, and this gorge was eaten back from the neighborhood of the village of St. David to the position of the present Whirlpool. The readvance of the glacier not only abolished this river but filled with drift the gorge it had made, so that one may now cross it on what is known as the Old Portage road without suspecting the existence of a buried valley.

When the ice for the last time melted from the land, it left a hollow which we know as the basin of Lake Erie and another hollow which contains Lake Ontario, and it left the face of the land in such shape that the overflow from one lake to the other could not follow the valley of an earlier stream but sought out a new course. Thus Niagara River was born; and its cataract has been engaged ever since in making the gorge.

Iroquois beach.

Just before the establishment of Lake Ontario there was a greater lake in the same basin, with an outlet to the Mohawk and the Hudson instead of the St. Lawrence. The abandoned shore of this greater lake, a shore called by geologists the Iroquois beach, lies close to the escarpment and can be traced by means of its bluffs and ridges. Its line is followed for many miles in New York by a road called the Ridge road, which is shown on the map. At Dickersonville it runs on a typical beach ridge of gravel and sand. Near Model City it is on top of the ancient shore bluff, and in Lewiston it is on a gravel ridge which was built as a spit in the old lake.

After the disappearance of the ice the land it had covered was gradually uplifted, but the rate of uplift was different in different places. As a result of this warping of the earth the outlets of certain large lakes were changed, and these changes had an important influence on Niagara River. There were two epochs during which most of the water of the Great Lakes region flowed to the ocean by other routes, leaving to the Niagara only the water from the Lake Erie basin. During these epochs the river was much smaller than it is now, probably carrying only one-eighth of the present amount of water, and the cataract was then a less powerful agent of erosion. The deeper parts of the gorge, which now contain pools, were excavated by the cataract when the volume of the river was large. The shallower parts, which now contain rapids, were excavated when the volume of the river was small.

Age of the river.

The determination of the age of the river, or the time which has been consumed in the making of the gorge, is a problem of great interest, to which much attention has been given. As the length of the gorge is known and as the rate at which the cataract now lengthens the gorge is known, it would seem a simple matter to compute the time. Taking the gorge length as a dividend and the annual change in length as a divisor, we obtain 7,000 as a quotient, and this has been assumed by some to represent the number of years spent by the river in the work. But this computation fails to take account of a number of important facts. The thickness of the limestone is not the same in all parts of the gorge; the height of the cataract was not the same through the whole period; and, as just pointed out, the volume of the river was sometimes much less than it is now. The fact last mentioned is the most important of all, for the diminished river would erode much less rapidly than the full river. If we knew precisely what difference the change of volume made we might obtain a fairly satisfactory answer to the problem, but this we do not know. The smaller of the two divisions of the cataract, known as the American Fall, now contains nearly as much water as the whole river did during times of diminished drainage basin. But the crest line of the American Fall had not changed its form appreciably from 1827, when the first accurate drawings of it were made, to January, 1931, when a considerable fall of rock occurred. Its recession must be many times slower than that of the Horseshoe Fall. This fact indicates that the rate of erosion of the narrowest parts of the gorge was exceedingly slow and that the time consumed was exceedingly long. We may say with some confidence that 7,000 years is altogether too small an estimate of the age of the river. An estimate based on the latest available data (1929) indicates that the time for the making of the postglacial gorge is probably about 18,000 or 20,000 years.